Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER I
SESSION 2020/2021

COURSE NAME	:	AIRCRAFT AERODYNAMICS
COURSE CODE	:	BDU 10703
PROGRAMME CODE	:	BDC / BDM
EXAMINATION DATE	:	JANUARY / FEBRUARY 2021
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **SIX (6)** QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **SIX (6)** PAGES

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Q1 (a) Sketch roughly Airfoil Terminology with statement and give definition on each of the statement.

(5 marks)

(b) Evaluate the aerodynamics characteristics for various aircraft components such as airfoil, wing and fuselage according to Airfoil NACA Series profile as shown in **FigureQ1(b)**.

(7 marks)

(c) Give examples for NACA 4,5,6 digit airfoils? Analyze this 2 Airfoil NACA Series on best performance according to subsonic, transonic and supersonic condition.

(8 marks)

Q2 (a) Develop Bernoulli's Equation for incompresible flow or as compresible flow. Find the relationship between pressure p and density ρ.

$$\frac{1}{2}dU^2 = -\frac{1}{\rho}dp$$

(6 marks)

(b) One of the ways of finding the flow patterns, velocities and pressures about streamlined shapes moving through an inviscid fluid is to apply a conformal mapping to the potential flow solution for a circular cylinder. The cylinder can be mapped to a variety of shapes including aerofoil shapes.
Use a Joukowski mapping to **produces** a family of elliptical shapes and streamlined aerofoils. By knowing the derivative of the transformation used to perform the geometry mapping, along with the original velocities around the cylinder, the velocities in the mapped flow field can be found.

(14 marks)

Q3 (a) List of 5 factors which influence to their aerodynamics characteristics.

(5 marks)

(b) The Cessna 172 aircraft has a wing geometry with aspect ratio (AR) of the Cessna 172 is given as 7.32, a wing area of 174 ft^2 and a gross weight of 2450 pounds. The velocity of the airplane is 5280 ft/mile. If the airplane is flying at 100 miles per hour on a standard day at sea level, If the wing has an elliptic lift distribution, find:

i. The lift coefficient; and

ii. The induced.

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(7 marks)

(c) Consider an NACA 2412 airfoil with a chord of 0.64m in an air-stream at standard sea level conditions. The freestream velocity 70 m/s. The lift per unit span 1254 N/m. Examine :

i. pressure and Reynold no,
ii. the angle of attack; and
iii. the drag per unit span.

(8 marks)

Q4 An airfoil 5 digits Naca series 23012 immersed in the flow field with the incoming free stream makes 5^0 angle of attack with respect to the airfoil's chord line. The camber line of this airfoil is given as:

$$\frac{z}{c} = 2.6595\left[\left(\frac{x}{c}\right)^3 - 0.6075\left(\frac{x}{c}\right)^2 + 0.1147\frac{x}{c}\right] \text{ for } 0 \leq \frac{x}{c} \leq 0.2025$$

$$\frac{z}{c} = 0.2208\left(1 - \frac{x}{c}\right) \text{ for } 0.2025 \leq \frac{x}{c} \leq 1.0$$

Using Thin airfoil theory, determine :

(a) the thin airfoil coefficient A_0, A_1 and A_2,

(10 marks)

(b) the lift coefficient C_l,

(4 marks)

(c) The pitching moment coefficient at the leading edge c_{mle}; and

(3 marks)

(d) The center of pressure c_P .

(3 marks)

Q5 The monoplane equation will be used to compute the aerodynamic coefficients of a wing for which aerodynamic data are available. The geometry of the wing to be studied is illustrated in **Figure Q5(b)**. The wing, which is unswept at the quarter chord, is composed of NACA-210 airfoil section. Referring to the data of Abbott and von Doenhoff (1949), the zero-lift angle of attack (α_{0l}) for this airfoil is approximately -1.2□ across the span. Since the wing is untwisted, the geometric angle of attack is the same at all spanwise positions. The aspect ratio (AR) of the full wing is 9.00, and the taper ratio $\lambda(c_t/c_r)$ is 0.40. Considering the wing planform is trapezoidal, an additional data can be given as:

$$S = \frac{1}{2}(c_r + c_t)b = \frac{1}{2}c_r(1+\lambda)b$$

And

$$AR = \frac{2b}{c_r + c_t}$$

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Therefore, the parameter μ in equation becomes:

$$\mu = \frac{ca_0}{4b} = \frac{ca_0}{2(AR).c_r(1+\lambda)}$$

Where c is the local chord, $c(y)$.

Using the Lifting Line Theory calculate the lift coefficient for this wing model.

(20 marks)

Q6 (a) There are 3 types of Shockwave. Describe each type of shockwave and explain each type with ilustration image

(5 marks)

(b) A two-dimensional double-wedge profile is at zero angle of attack in an air stream of Mach number 2.0. as shown in **Figure Q6(b)**.
The oblique shock relations used to determine the conditions in region 2.
$Ma_1 = 2.0,\ \delta_{12} = 10° \Rightarrow Ma_2 = 1.6405,\ \varepsilon_{12} = 39.31°,\ p_2/p_1 = 1.7066$
With Mach number in region 3 using the Prandtl-Meyer angle
$Ma_2 = 1.6405 \Rightarrow \nu_2 = 16.0574°$
$\nu_3 = \nu_2 + \delta_{23} = 36.0574°$ where $\delta_{23} = 20°$
$\nu_3 = 36.0574° \Rightarrow Ma_3 = 2.3717$

Distinguish:
(i) The pressure ratio for region 3 using the isentropic relations,
(ii) C_d drag coefficient ; and
(iii) Solve C_d drag coefficient using thin airfoil theory.

(15 marks)

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-END OF QUESTION –

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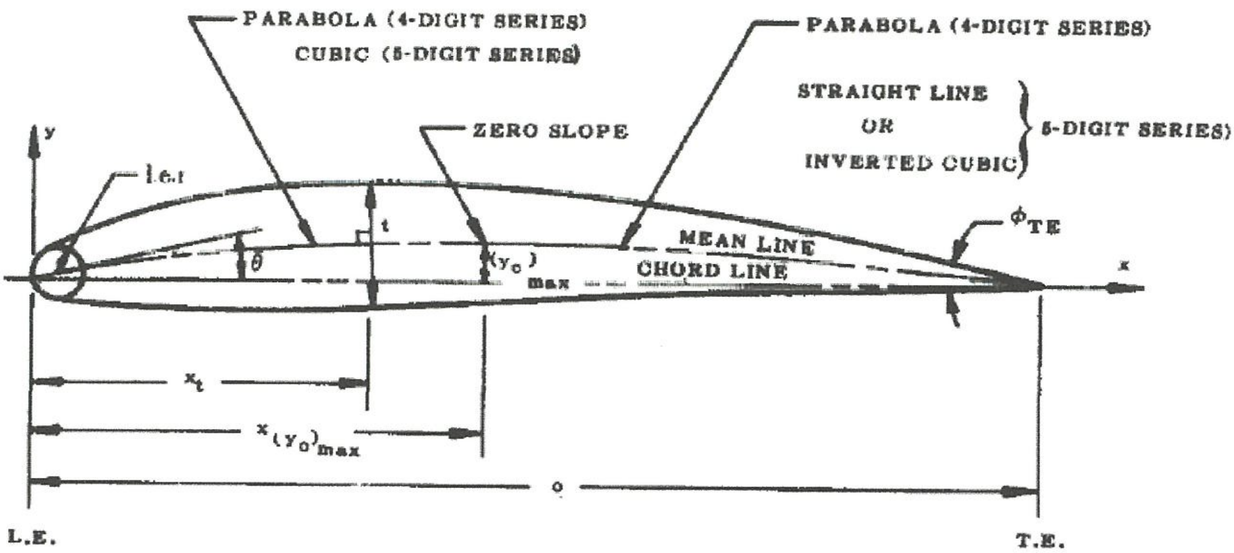

Figure Q1(b)

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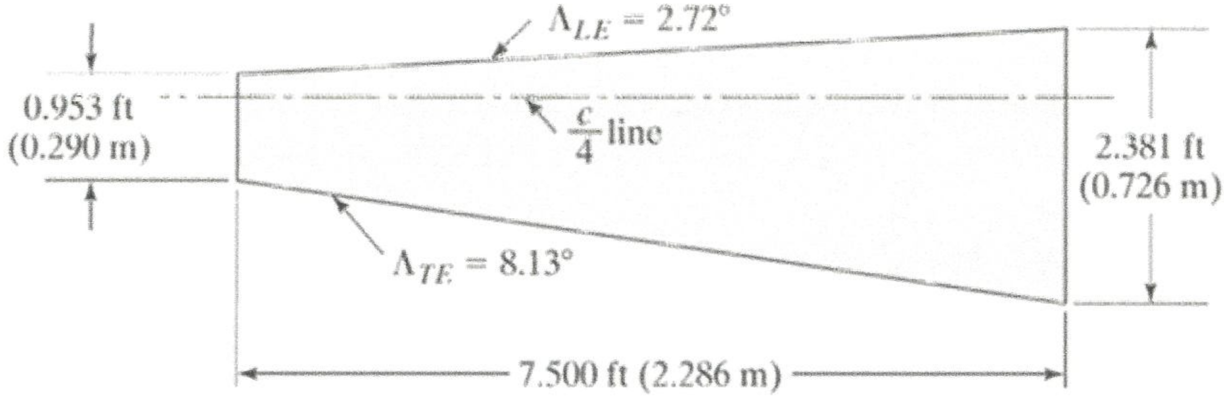

Figure 5(b)

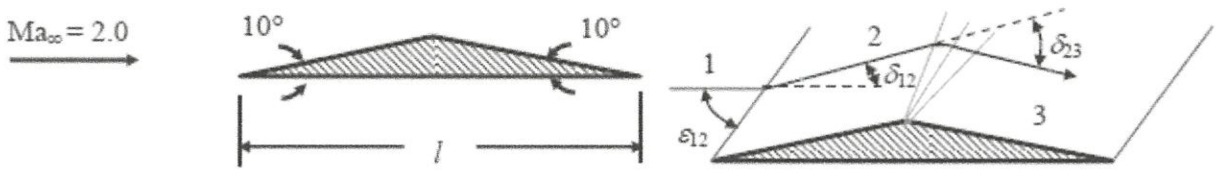

Figure 6(b)

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